A new approach for checking and complementing CALIPSO lidar calibration

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Different possible targets for studying 1064 nm CALIPSO calibration

Cirrus clouds:

Principal error sources: complexity of ice particles, multiple scattering

Principal advantage: cleanest in term of aerosol contamination

Ocean surface:

Principal error sources: boundary layer aerosols are likely to be always present, subsurface contribution at 532 nm

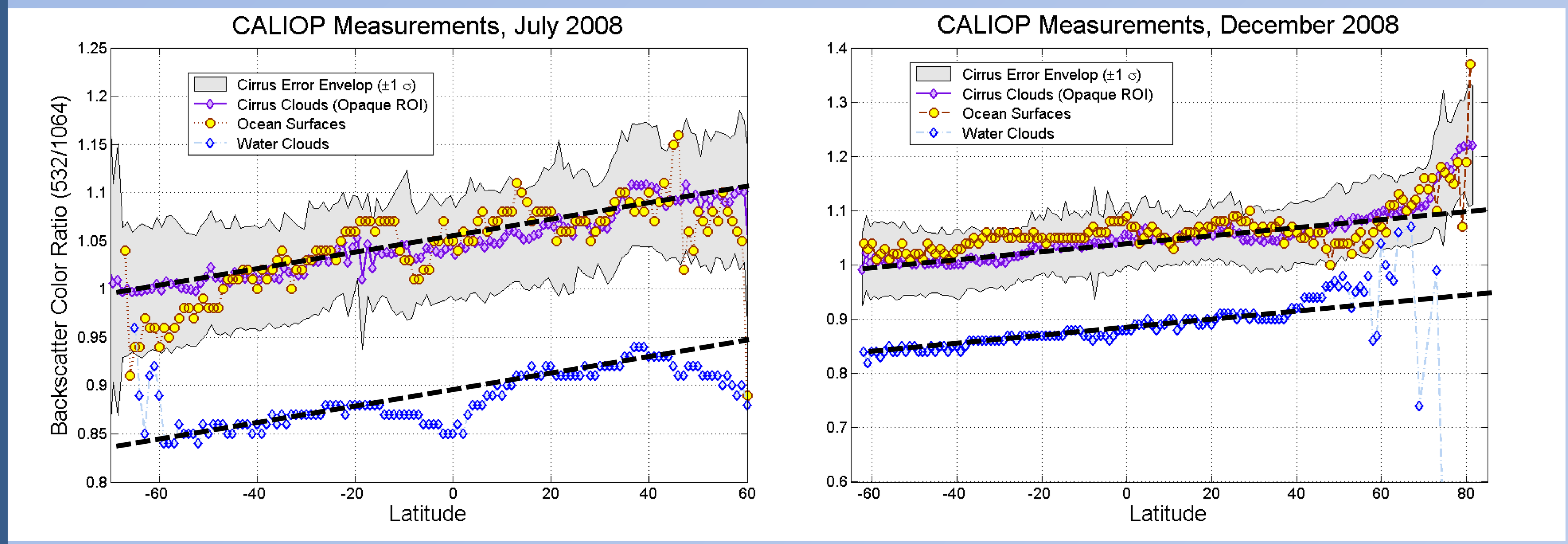
Principal advantage: surface backscatter contribution is well characterized

Water clouds:

Principal error sources: aerosol presence higher than for cirrus (but lower than ocean surface), multiple scattering

Principal advantage: spherical droplets are well characterized by Mie theory.

Using 532 nm channel as a reference for 1064 nm (ocean surface, liquid water clouds and cirrus)



We have been studying the backscatter ratio of the two CALIPSO wavelengths for 3 different targets. We are showing the ratio of integrated attenuated backscatter coefficient for cirrus clouds, ocean surface and liquid Water clouds for one month of nightime data (left: July, right: December),

Only opaque cirrus classified as randomly oriented ice [1] are used. For ocean and water clouds, only the clearest shots, determined by a threshold on integrated attenuated backscatter are used.

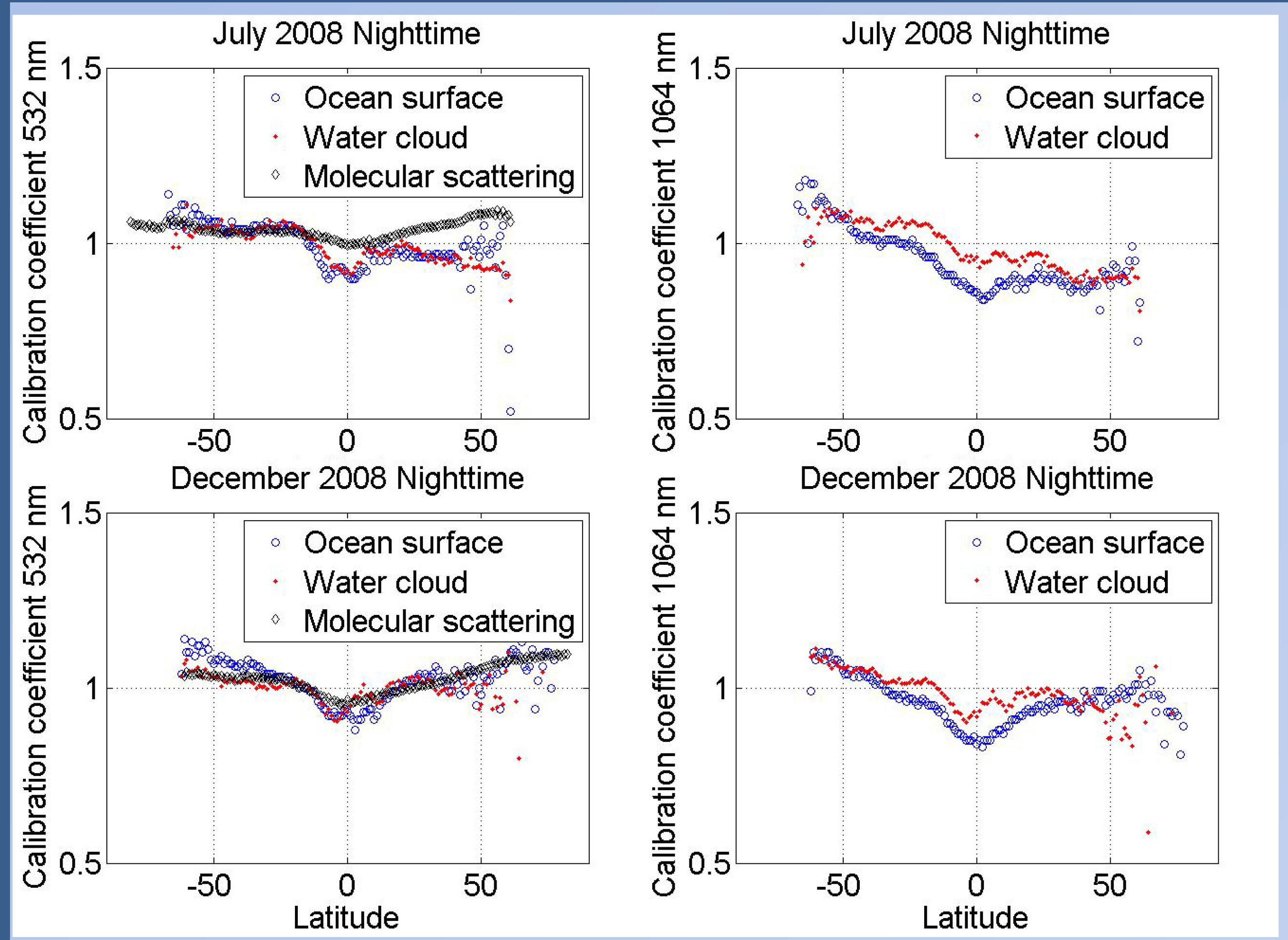
Two things can be immediately observed:

1. A similar trend (black dotted line) is visible using all targets, the color ratio shows a tendency to be higher north and lower south for those two month.
2. The water clouds average value is around 15% lower than ocean surface and cirrus clouds. This is due to the different multiple scattering at 532 nm and 1064 nm [2] which strongly impact the water cloud retrieval.

Discussion: the similar trend is a strong indication that the relative difference between both wavelength is an instrumental effect and is not linked to the geophysical properties of the observed features. Moreover, as this trend is clearly visible despite the different error sources, it would suggest if the number of observations is high enough, those errors do not affect the general trend but increase the dispersion around this trend and can create a bias. This is clearly observable and further research will be conducted on this subject. They will include:

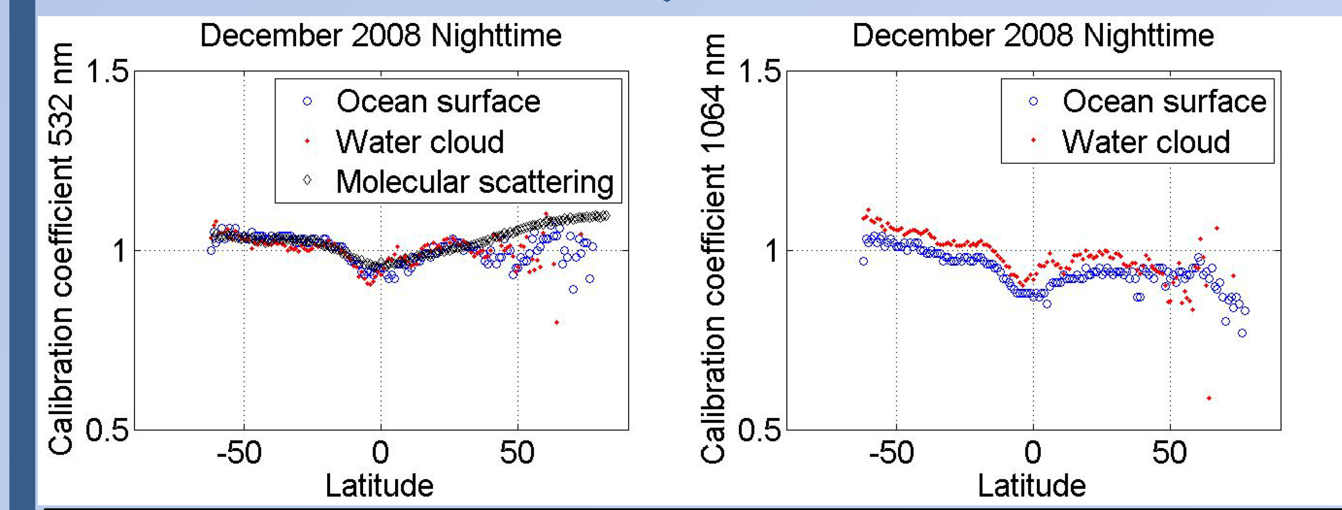
1. Simulation of multiple scattering in lidar signal [3]
2. More theoretical work on subsurface return on the CALIPSO signal. We conducted some theoretical improvement of the lidar equation for ocean [4] and we will go further.

Analysis of 532 nm and 1064 nm channel separately



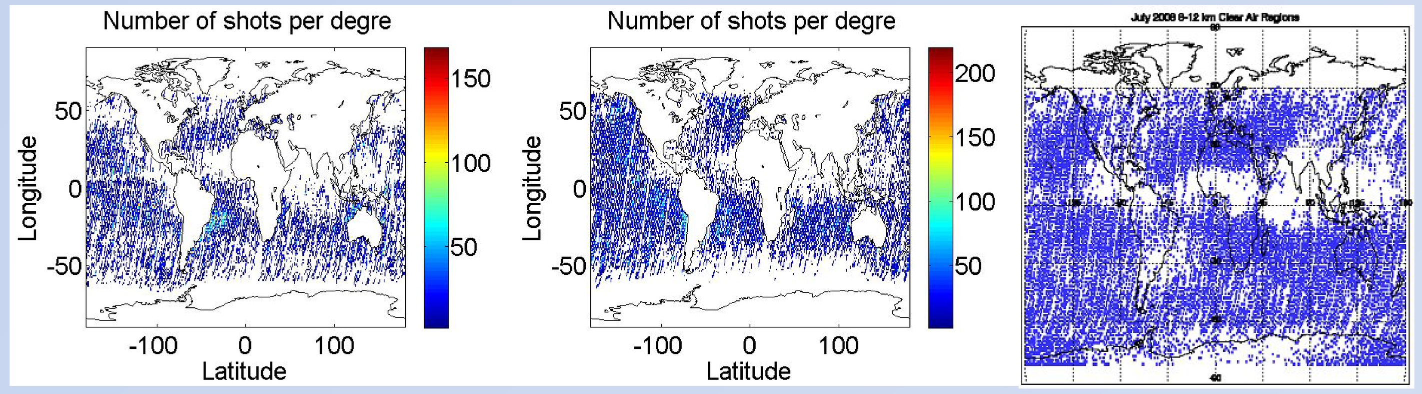
3 different targets have been used for 532 nm calibration. The ocean surface, liquid water clouds and molecular air between 8-12 km on clearest conditions. For ocean surface, the reference is provided by CLOUDSAT normalized scattering cross section [5] corrected by the water vapor integrated content of AMSR-E [6]. For water clouds, the reference is provided by the lidar perpendicular channel [7]. For molecular air, the reference is provided by the air density profile of GMAO.

For 532 nm, ocean surface and water clouds show an important degree of similitude for both month. They compare well for December 2008 but the agreement is lower for July. We believe this come from a sampling effect as molecular method sample the whole earth but only ocean area are sampled by ocean and water cloud method.



After application of the new water vapor correction, the agreement is increased between the 3 methods.

As we can see, there are still some differences between CALIPSO calibration using CLOUDSAT as a reference and CALIPSO polarization. In fact, CLOUDSAT water vapor correction can be improved by analyzing the collocated CALIPSO/CLOUDSAT ocean surface echo on clear air. Lowering the dispersion of the data allows to improve existing millimeter propagating wave models. Once this new model is applied to CLOUDSAT water vapor, we can see an improvement of the comparison of ocean surface and water clouds calibration at both 532 and 1064 nm. The bias in 1064 nm is coming from the different multiple scattering.



Map of number of observations for ocean surface (left), liquid water clouds (middle) and molecular return (right, generally one 200 km sample when colored) for July 2008. Differences are especially important in the northern hemisphere where most of the continental mass are present. It is where we can find the highest differences between the molecular return and both other methods.

Conclusion:

Different targets can be used to improve CALIPSO 1064 nm calibration accuracy. All of them show the signature of an instrumental calibration shift.

Multiple scattering introduce a biais in liquid water cloud signal but it still compares very well with all other methods and should not be overlooked. The effect of multiple scattering in liquid and ice clouds will be the subject of future research.

If there really is a sampling issue Combining all method to. to increase the sampling, mapping the calibration coefficient or trying to reach an orbit per orbit calibration seems an appropriate way

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